Self-Balancing Robot

Overview

An inverted pendulum system is a highly coupled multivariable, nonlinear, unstable system. It is the perfect experimental device to examine various control theories. Controllability, stability, robustness and some other key performance in control will be examined in the process of controlling such system.
The self-balancing robot is in fact a movable 3 Dof inverted pendulum system. The system, taking the gyro as feedback, is balanced by outputting different torque in two wheels.

System Characteristic

1. More degree of freedom compare to linear and planar inverted pendulum
2. Using real-time workspace in MATLAB.
3. Embedded PC104 system with windows operating system
4. Online editing and modifying the control algorithm.
5. Various extension interface for add-on sensors, e.g. vision
6. Providing MATLAB functions

System Model

$$\begin{bmatrix} \dot{x}_r \\ \ddot{x}_r \\ \dot{\theta}_p \\ \ddot{\theta}_p \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & A_{23} & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & A_{43} & 0 \end{bmatrix} \begin{bmatrix} x_r \\ \dot{x}_r \\ \theta_p \\ \dot{\theta}_p \end{bmatrix} + \begin{bmatrix} 0 \\ B_2 \\ 0 \\ B_4 \end{bmatrix} [C_\theta]$$

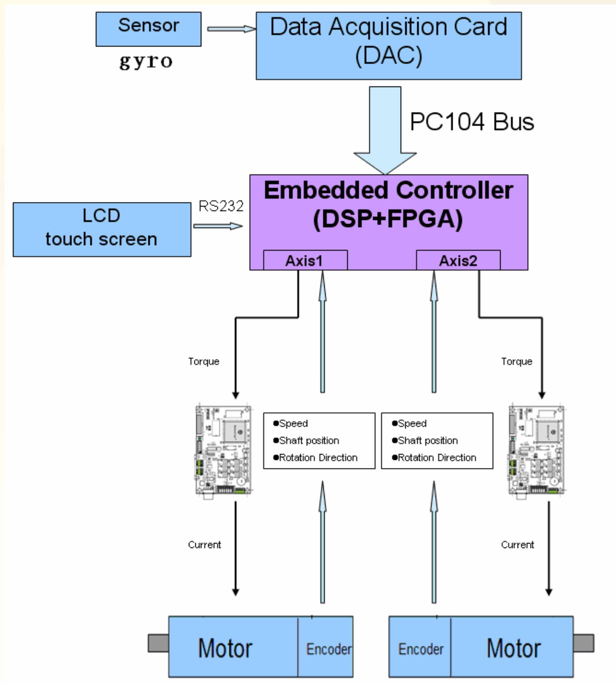
$$\begin{bmatrix} \dot{\delta} \\ \ddot{\delta} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \delta \\ \dot{\delta} \end{bmatrix} + \begin{bmatrix} 0 \\ B_6 \end{bmatrix} [C_\delta]$$

x_r Robot Position

θ_p Robot Tilting angle

δ Robot Yaw angle

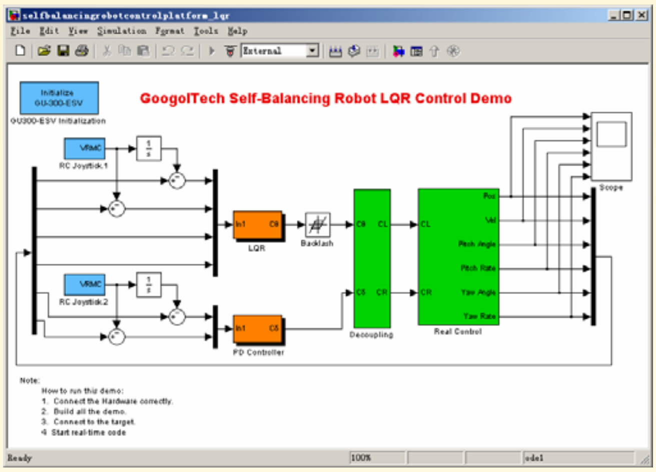
C_θ, C_δ Torque of motor

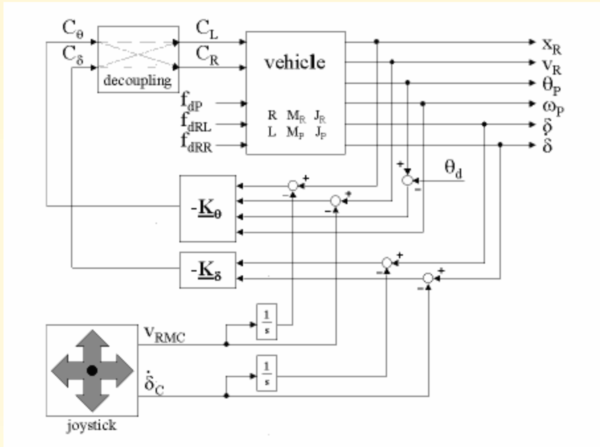


System Diagram

Reference Experiments

- Gyro application and experiments.
- System Modeling
- Open Loop System Analysis
- PID Controller Design
- Pole Placement Controller Design
- LQR Controller Design
- User Defined Controller Design





MATLAB Interface

Plant diagram

Specifications

L×W×H	*260mm×450mm×730mm*
DC Servo Power	85W
Gear Ratio	8:1
Motion Controller	✧ DSP and FPGA based embedded controller ✧ PC104 Bus ✧ 3 Axes Motion Controller
Software Envir.	WIN98/MATLAB6.5
Maximum Speed	1.6m/s
Power	NiMH Battery 8.5Ah(24V)
Duration	>1.5 H
Maximum Ramp Angle	20 Degree
Gyro	➢ Power 9~12V ➢ AD/DA resolution 12bits ➢ Current 30mA ➢ Maximum angular velocity ±300deg/sec(25˚C) ➢ Range 360˚ (25˚C) ➢ Sampling Frequency 150HZ ➢ Temperature Bias ± 0.025%/˚C ➢ Operating Temperature -40~50˚C ➢ Analog Output (0~4.096V) ➢ Repeatability 0.10˚ ➢ Weight 20g

Ordering Guide

Model Number	Product Name	Product Configuration
GBOT1001	Self-Balancing Robot	ABOT-MB-1001 Self-Balancing Robot Main Body ABOT-CS-1001 Self-Balancing Robot Software S-UP-MAT GoogolTech's Simulink Toolbox